

# Scalable High-Order Finite Element Discretizations and Solvers With MFEM, Hypre and BLAST

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## Abstract

High-order finite element discretizations are a natural fit for future HPC hardware, because their order can be used to tune the performance, by increasing the FLOPs/bytes ratio, or to adjust the algorithm for different hardware. In this talk we present our work on scalable high-order finite element software that combines the modular finite element library MFEM [1], the hypre library of linear solvers [4], and the high-order shock hydrodynamics code BLAST [2,3]. We discuss the finite element abstractions provided by MFEM, which include arbitrary high-order H1-conforming, discontinuous (L2), H(div)-conforming, H(curl)-conforming and NURBS elements, defined on general high-order meshes. We explain how the MPI-based version of MFEM uses data structures and kernels from the hypre library to enable scalable finite element assembly in parallel. We describe the efficient implementation of high-order force matrices in the MFEM-based BLAST application, where we will also demonstrate the benefits of our approach with respect to strong scaling and GPU acceleration. Finally, we consider general non-conforming high-order adaptive refinement in MFEM with applications to compressible hydrodynamics in BLAST and computational electromagnetic problems.

## References

1. MFEM LIBRARY. "Modular finite element library". <http://mfem.org>.
2. BLAST PROJECT. "High-order shock hydrodynamics". <http://llnl.gov/casc/blast>.
3. V. DOBREV AND TZ. KOLEV AND R. RIEBEN. "High-Order Curvilinear Finite Element Methods for Lagrangian Hydrodynamics". *SIAM Journal on Scientific Computing*, (34) 2012, pp.B606–B641.
4. HYPRE LIBRARY. "Scalable linear solvers library". <http://llnl.gov/casc/hypre>.